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THE U.S. AND THE SOVIET UNION ACCELERATE DEVELOPMENT OF ANTISATELLITE WEAPONS

Ren Gouguang

ABSTRACT This article describes the development programs of anti-satellite weapons in the United States and the Soviet Union. It also reviews new progress in antisatellite technologies.

KEY WORDS Antisatellite missile, Interception satellite Laser.

Not long after the Second World War, the U.S. and the Soviet Union then recognized the potential military value of space--the reason being that space provides the possibility of carrying out omnidirectional surveillance of the earth. A good number of strategists believe that space is the main battlefield for the wars of the future. Whoever is able to seize supremacy in space will then be capable of changing the balance of military forces. Satellites possess a very important role with regard to the safety of a nation. In peace time, satellites supply guarantees with regard to threat forces as well as verification of international treaties. In war time, they will very, very greatly improve military combat power--playing a role in strengthening military forces. At the present time, reconnaissance, early warning, command, communications, navigation, nuclear explosion monitoring, and metrological satellites have already become important consituent parts of U.S. and Soviet military forces. In order to seize superiority in space, it is then necessary to develop various types of antisatellite weapons.

The U.S. and the Soviet Union began the development of various types of antisatellite technology at the end of the 1950's--including early antisatellite missiles carrying nuclear warheads and coorbital counter satellites. Later, they were such

things as antisatellite missiles carrying conventional warheads as well as kinetic interception missiles and directed energy weapons technology, etc. Although, at the present time, U.S.-Soviet relationships have softened somewhat, and both sides are

engaged in cutting their respective overall military budgets as well as trimming conventional forces, they still, however, both

are involved in accelerating the development of antisatellite weapons. It seems that both the U.S. and Soviet sides recognize that, when overall military forces are reduced, the multiplier effect of space systems on military power is then even more important.

The U.S. already began implementing new antisatellite projects in 1989. They will borrow for use two different types of SDI (strategic defense initiative) technologies to develop kinetic energy and laser counter satellite weapons. As far as progress achieved on the basis of SDI technology is concerned, it will not be long until it causes counter satellite objectives to be actualized. The White House has requested giving antisatellite projects appropriations of 208 million U.S. dollars in fiscal year 1991. This is a 180% increase in expenditures compared to fiscal year 1990--making them one of the weapons which are developing the most rapidly. In 1996, the Department of Defense plans for initial deployment of ground based kinetic energy antisatellite weapons. In fiscal year 1997, there will be deployment of ground based laser antisatellite weapons.

From 1971 on, the Soviet Union was then able to make use of coorbital types of antisatellite weapons to attack U.S. low orbit satellites. In conjunction with this, they could jam satellites at various types of orbital altitudes. Besides this, they also possessed other systems having antisatellite capabilities. These included antiballistic missiles (ABM) in the vicinity of Moscow for interception and land based experimental lasers associated with Saleishagan (phonetic). Even though we are in a new situation, and the Soviet Union has recently reduced its conventional strength, and, in conjunction with that, has cut overall military expenditures, it has, however, still continued to carry out huge investments with regard to military space

projects--improving military space capabilities. In 1989, the Soviet Union appropriated 4 billion rubles to use in military space projects. The Soviet Union's civilian space programs have already been curtailed. However, there has certainly not been a trimming of their military space programs--including coorbital types of antisatellite weapons.

II. SATELLITES AND COUNTER SATELLITES

Speaking in terms of a nation's actual strength in space, satellites and counter satellite weapons are two of the most important factors. Following along with the development of space technology, military applications associated with space have very rapidly spread to various domains. Satellites have already become indispensible constituent parts of the military structures of the two super powers. Up to the present time, the entire world has launched a total of 3956 satellites. Among these, the Soviet Union has 2561. The U.S. has 1119. Military satellites account for 70%. At the present time, the Soviet Union has operating in orbit each day satellites and back up satellites reaching 150. Military satellites account for 90%. The U.S. has approximately 100 satellites. /27

Despite the fact that satellites possess extremely important military value--this is, in particular, even more the case when military strength is being reduced--satellites are, however, still very delicate. The reason is that their orbits in space are fixed. Moreover, space is open. Satellites are placed under surveillance by various types of monitors and are not subject to any restrictions. Of course, satellites can opt for the use of

various types of countermeasures in order to protect themselves. However, no matter what types of methods are opted for in order to improve satellite survivability, it is very difficult in all cases to make them successfully resist current and future antisatellite weapons. The objectives of the development of antisatellite weapons by the two nations--the U.S. and the Soviet Union--are as follows. One is to possess in war time the capability to attack the other side's satellites. Second is to play a deterent role, making the other side not dare to lightly make use of antisatellite weapons.

The fragility of satellites--to a very great extent--depends on the orbits in which they are placed. These orbits are roughly divided into:

--Low Orbits. Satellite orbit altitudes lower than 5000km. These are the only satellites that can be easily subjected to attacks by antisatellite weapons currently on hand. The two nations--the U.S. and the Soviet Union--deploy in this type of orbit satellites including optical reconnaissance satellites, electronic intelligence satellites, weather satellites, and manned spacecraft. The Soviet Union also deploys in this type of orbit communications satellites and radar oceanographic monitoring satellites. In reality, all of these Soviet satellites are in orbits under 1500km.

--High Elliptical Orbits. Soviet strategic early warning satellites, military, and civilian satellites have all been placed in this orbit. They are capable of being subjected to attacks by kinetic energy antisatellite weapons which were developed at an early stage by the U.S.

--Semisynchronous Orbits. Orbital altitudes are 20 thousand km. Global navigation satellite systems (the U.S. Navstar system and the Soviet GLONASS system) are placed in this type of orbit.

It is forecast that, within ten years, antisatellite weapons will still not be able to reach this type of range.

--Geoynchronous Orbits. Orbital altitudes are 36 thousand km. The U.S. has a good number of military communications satellites, strategic early warning satellites, electronic intelligence satellites, and nuclear detonation detection satellites that are all positioned in this orbit. At the present time, the Soviet Union only has communications satellites positioned in this orbit. It is forecast that, ten years from now, the Soviet Union will have more numerous military satellites appear in geosynchronous orbits.

At the present time, most Soviet satellites are positioned in low earth orbit. They are easily subject to attack by antisatellite weapons. However, the number of Soviet satellites in orbit is large, and satellite replacement rates are high. This is capable of partially compensating for the shortcoming of bad satellite survivability. Besides this, as far as the functions of Soviet satellites are concerned, they are single. During military operations, dependence on satellite procedures is low. Because of this, even if they have been destroyed, there is still no great damage. Compared to Soviet satellites, U.S. satellite orbital lives are long. Performance is good. They possess multiple types of functions. Moreover, important satellites are all deployed in synchronous orbits which are at present difficult to attack. However, due to the fact that the numbers of U.S. satellites are small, their prices are high, levels of dependence of military activities on satellites are high, and they are also difficult to replace, it will, therefore, be disadvantageous to the U.S. in antisatellite wars of the future.

III. THE SOVIET UNION'S ANTISATELLITE WEAPONS

1. Coorbital Types of Antisatellite Systems. Coorbital types of antisatellite systems use carrier rockets to fire interception devices into coplanar orbits with satellites. After that, maneuvers are carried out to change orbit. Using coorbital methods or methods associated with rapidly flying past from the side, when satellite targets are approached, a conventional warhead is detonated destroying the satellite. Terminal guidance associated with this type of interception device is capable of making use of radar or infrared detectors. In 1968, the Soviet Union carried out initial antisatellite tests. From then on, a total of 20 iterations were carried out. Among these, 9 were successful. 11 tests failed. Although, after 1983, the Soviet Union stopped testing with regard to coorbital types of antisatellite weapons, they still, however, make appropriations for use in order to improve the weapon performance.

This type of Soviet antisatellite weapon is very cumbersome. The weight exceeds 2000kg. It is launched into orbit by a liquid booster refited from an old style SS-9 intercontinental ballistic missile. The U.S. Defense Department estimates that this type of antisatellite weapon is capable of intercepting satellites at altitudes of 5000km. However, the maximum intercept altitudes associated with Soviet tests were only 1600km. This type of weapon--besides test performance being bad--also has several drawbacks. (1) It is only capable of intercept when the surface sweep trace of the target closely approaches the antisatellite launch position. (2) This type of weapon is too heavy. It requires large model boosters. As a result, it is only capable of using the small number of launch systems which the Soviet Union currently has for firing. (3) This type of large model liquid booster is very difficult to rapidly and continuously fire from single positions.

2. Sky Mines. Sky mines are a type of inexpensive antisatellite weapon. It is said that they are capable of being used in order to cope with U.S. star wars defense weapons. The Soviet Union is just in the midst of considering making sky mines. When countering satellites, sky mines go ahead of and evelop U.S. strategic defense systems. At the necessary time, they can be remotely controled, causing the explosives in them to blow up, destroying the target. Generally speaking, sky mines are capable of threatening satellites at any altitude.

3. Laser Antisatellite Technologies. The Soviet Union has been involved right along in research on and development of laser, particle beam, and radio frequency weapons. In the area of laser antisatellite weapons, according to estimates, the Soviet Union already has two high power laser system units possessing antisatellite capabilities. They are capable of causing low earth orbit satellites to be blinded or destroyed. Moreover, they have also constructed a new laser antisatellite system at Nulieke (phonetic).

According to estimates, the Soviet Union's lasers are capable of creating structural damage against satellites at altitudes of 403-563km. In conjunction with this, they are able to damage solar powered battery panels associated with satellites at orbital altitudes of 2737km. In July 1989, a number of U.S. scientists toured the Saleishagan (phonetic) missile test range. It has been considered to be the Soviet Union's largest laser weapon test range. The largest laser system the visitors saw was a 20kW continuous wave CO2 laser unit. It was connected to a beam direction device with a diameter of 1 meter. The power of this laser unit was only one percent that of U.S. intermediate

infrared high power chemical lasers. Moreover, wavelengths were also long. The U.S. Defense Department recognizes that this laser unit is certainly not capable of causing satellite vaporization or explosion. However, it can cause sensitive detectors or other components to go out of order. As far as 1MW pneumatic CO2 lasers of the Soviet Union's Kuerqiatuofu (phonetic) research institute are concerned, despite the fact that they have not had military testing carried out on them in association with the necessary beam direction devices, their megawatt level output powers, however, make them enter into the catagory of high power laser weapons. /28

IV. U.S. ANTISATELLITE TECHNOLOGIES

At the end of the 1950's, the U.S. began research on antisatellite technologies. In the early 1960's, deployment was begun of two types of ground based nuclear powered antimissile systems--that is, antimissile systems carrying megaton yield nuclear warheads and firing the Army's Nike III missile and the Air Force's Thor missile. They were also capable of being used against satellites. However, nuclear detonations in space would, at the same time, destroy one's own and friendly satellites within several thousand kilometers. Moreover, testing and utilization were both subject to limitations. The Nike and Thor systems were respectively retired in 1964 and 1975. From the latter half of the 1970's, the U.S. began developing conventional rocket round antisatellite weapons and high power laser technologies. Following along with implementation of the star wars projects, a good number of advanced technologies developed in association with SDI were turned to research work on antisatellite weapons. At the present time, the U.S. is in the midst of carrying out new antisatellite projects--including kinetic energy weapons and laser weapons. Responsibility was taken for the development of kinetic energy weapons by the combined antisatellite projects office led by the Army. Carried out in parallel with this was work on laser back up designs which were capable of satisfying antisatellite requirements and were explored respectively by the Army and the Air Force. Due to the fact that land based laser technology is still not mature, there exist a good number of difficulties--in particular, transmission problems associated with ground based lasers passing through the atmosphere have still not been resolved. Besides this, the utilization of ground based lasers is subject to very great influences from weather conditions. As a result, the Defense Department believes that developing two types of antisatellite

weapons system is very important. In this way, they are able to mutually complement each other, and, in conjunction with that, work in coordination.

1. U.S. Kinetic Energy Antisatellite Weapons. After 1975, the U.S. began to develop nonnuclear rocket rounds as antisatellite weapons--for example, small models of automatic homing craft launched aerially. They are one type of kinetic energy weapon which does not carry a charge. They are fitted on a two stage rocket fired from the F-15 fighter. In September 1985, the first antisatellite target tests were carried out. Above the Pacific Ocean, an abandoned satellite was destroyed. Later, due to the fact that the U.S. would stipulate in public law a prohibition against making tests associated with antisatellite missiles intercepting targets in space, and the White House and high level military officials also were not too supportive of this type of antisatellite weapon, therefore, the entire project was canceled in March of 1988.

The time interval did not reach a year. The Defense Department again decided in 1989 to begin developing antisatellite weapons anew. It was calculated that, within the following 5 years, 140 million U.S. dollars would be used to develop kinetic energy antisatellite weapons. The purpose was to develop satellite interception rounds to deal with satellites in orbits lower than 2000km. In July 1990, the Army and Rockwell International company signed a two year 100 million U.S. dollar contract to design kinetic energy antisatellite systems. As far as antisatellite missiles associated with the project are concerned, diameter is 61cm. Length is 9m. Weight is 3515kg. The kill and damage flight craft carried are 1m long and weigh 68kg. In conjunction with this, use is made of an "added kill and damage system". It is capable of expanding or developing

into a fan shape in order to enlarge the surface area of the weapons. Kill and damage flight craft have adequate maneuver flight energy stored. In conjunction with this, they possess the capability of making flight maneuvers in orbit in order to facilitate intercepting satellites which are capable of evading. As far as carrying out this type of project is concerned, carrier rockets are already no problem because rocket technology currently on hand is already capable of taking kill and damage flight craft and accelerating them to 6.8km/s. Although kill and damage flight craft are the key to the project, they will, however, use the foundation of warhead interception systems technology outside the atmosphere developed in SDI. As a result, the development of this type of kinetic energy antisatellite weapon certainly does not constitute a big technical problem. The inerital guidance and optical detection devices opted for the use of in kill and damage flight craft are capable of borrowing for use technologies associated with warhead interception devices outside the atmosphere. Antisatellite kill and damage flight craft will opt for the use of dual mode homing devices. They are capable of operating in visible light and long wave infrared wave bands. This type of fixed view visible light detection device is capable of detecting targets more than 3000km away by solar irradiation. It possesses a view field associated with 650x650 image element homing devices which are 4°x4°. 130x130 image element infrared detection devices are capable of detecting targets 550-1000km away and assisting in the recognition of satellites and decoys. Infrared homing devices are also capable of detecting satellites which are flying through the penumbra of the earth.

2. Laser Antisatellite Weapons. Laser antisatellite weapons have a good number of obvious advantages. First of all, high power lasers provide the greatest potential against

intermediate orbit and high orbit satellites. Second, laser antisatellite systems possess the advantage of being able to be used repeatedly. In actuality, they are able to supply limitless, cheap "rounds". Third, ground based lasers fired at synchronous orbits only need 0.14 seconds. As a result, they are able to cope with satellites opting for the use of a good number of counter countermeasures such as maneuvering flight--creating for satellites a threat which is greater than kinetic energy weapons which ascend directly. Fourth, lasers can be used in order to destroy satellites at instants of severe resistance. However, in situations which are not extremely critical, it is also possible to make use of laser soft kill and damage to make enemy satellites slowly malfunction.

Due to laser antisatellite weapons possessing the advantages described above, they, therefore, act as the object of development which is focused on. The Army and Air Force are just in the midst of respectively exploring laser weapon back up designs which are capable of completing antisatellite missions. In 1991, Department of Defense procurement committees are scheduled to select a design from among them. After that, it goes into a one year demonstration and verification phase. It then goes through a 4 year large scale development and will be deployed in fiscal 1997. The Department of Defense estimates that development costs are 2 billion U.S. dollars. Speaking in terms of the present time, costs and test limitations are the greatest obstacles associated with the development of antisatellite weapons.

(1) Army Laser Antisatellite Projects. The projects in question include free electron lasers (FEL) and medium infrared advanced chemical lasers (MIRACL). Due to high output powers, FEL are capable of destroying medium and high orbit satellites and have become a prime candidate as laser antisatellite weapons.

MIRACL output powers are limited, and wave lengths are long. Moreover, it is difficult to develop them into systems for actual warfare. They are only capable of use in research experiments associated with countering satellites and the vulnerability of satellites to damage. /29

--Free Electron Lasers. As far as the Army's land based FEL antisatellite research work is concerned, it is carried out in parallel with SDI White Sands missile range FEL projects. However, it opts for the use of FEL technologies and systems that are used in antimissile research. Land based laser antisatellite weapons and land based antimissile weapons are capable of opting for the use of the same technologies. However, the lasers required for using land based lasers to cope with satellites will be much smaller. On the basis of calculations, if one wants to attack a low orbit satellite at an altitude of 1000km, the laser output power needed is 40MW. Despite the fact that land based laser antisatellite weapons only require comparatively low powers, they must, however, be capable of hitting targets moving at speeds of 6.9km/s. Laser weapons associated with BMD (ballistic missile defense) systems will launch beams to relay reflectors. These work together with targets and can act as beacons. They are capable of supplying important information relating to atmospheric turbulence and beam transmission. On the other hand, antisatellite engagements certainly do not require space based reflectors. Therefore, antisatellite systems then have beam control and precision aiming problems which are even more complicated than BMD systems. As a result, option for the use of land based lasers to destroy low orbit and medium orbit satellites requires very great improvements in the capabilities associated with White Sands missile range beam direction devices.

Due to large budget cuts in SDI, the scale of free electron laser technology integrated testing has already shrunk. However, there is still a need to spend 1 billion U.S. dollars. At the present time, White Sands missile range is in the midst of

building FEL with average powers of 1.5MW, light beam direction devices with diameters of 1.5 meters, and laser wave lengths of 1μm. Laser devices will opt for the use of oscillator-amplifier structures. In conjunction with this, construction uses building block methods. The initial construction of oscillators acts as the first step. The Boeing company's FEL projects opt for the use of 120MeV radio frequency linear accelerators. The accelerators are divided into a total of 5 sections. Each section is supplied power from radio frequency klystron tubes. Operating frequency is 1.3GHz. Accelerators opt for the use of constant gradient traveling wave structures in order to facilitate situations associated with the appearance of appropriately wide beam load ranges (electrical voltages and currents) in experimental series. FEL vibration device lengths are 5 meters. Option is made for the use of permanent magnets associated with variable tapers. Vibration devices are divided into 10 sections in order to facilitate the providing of high interaction intensities. This is what is needed in the achieving of visible light wave length high efficiency laser operation.

--Medium Infrared Advanced Chemical Lasers. Output powers are 2MW. Wave length is 3.8μm. The origin was construction by the Navy for use in order to defend against cruise missiles and aircraft. Later, they were used by SDIO in SDI damage vulnerability as well as kill and wounding studies. In December 1988, the Defense Department decided to make use of them in contering satellites and satellite damage vulnerability studies. Defense experts hoped to measure the level of damage to U.S. satellites associated with this type of laser in order to facilitate the understanding of satellite weaknesses. Other tests will provide outcome data associated with the propogation of laser beams through the atmosphere. In order to carry out antisatellite tests, it was necessary to improve light beam direction devices, making them capable of tracking and attacking satellites in space. Due to Congressional opposition to carrying out target tests in space, the Defense Department, therefore,

planned, in 1991, to carry out experiments associated with attacking flying targets in the atmosphere.

(2) Air Force Laser Anitsatellite Projects. The Air Force is in the midst of exploring two types of ground based laser antisatellite technologies. These are nothing other than quasimolecular lasers and oxygen iodine chemical lasers. These two types of lasers have still not been calibrated to high powers. Potential is limited. However, in the short run, the U.S. has only planned to deal with Soviet low orbit reconnaissance satellites. As a result, they have the possibility of becoming an antisatellite weapon in the near term.

--Oxygen Iodine Chemical Lasers. As far as the oxygen iodine chemical lasers that have been studied by the Air Force Weapons Laboratory (AFWL) are concerned, compared to MIRACL, they possess short wave lengths and high efficiencies. In conjunction with this, due to the fact that they are "stored energy" chemical systems, they possess the advantage of repetition frequency pulse operations. Recent research work has achieved progress. Output powers have reached 35kW. In conjunction with this, very good light beam quality has been obtained. Compared to FEL, although the concept of oxygen iodine lasers makes use of simple chemical principles and, as a result, in technical terms, risks are comparatively small, it is, however, not very possible to calibrate them to powers associated with the levels to counter satellites.

Oxygen iodine chemical lasers are, at the present time, the chemical lasers with the shortest wave lengths ($1.35\mu m$).

In an Air Force demonstration project, oxygen iodine lasers were taken and calibrated into MW level antisatellite weapons. The principal problem associated with the development of high power oxygen iodine lasers is to raise the level associated with chemical energy sources and the efficiency associated with the conversion of chemical energy into laser energy. The greatest difficulty in this is nothing else than the need to find a type of method capable of using chemicals to produce large amounts of

oxygen molecules in excited states. Reports of the U.S. physics society estimate that AFWL systems will produce 1MW beams. There is then a need for 40 supersonic nozzles laid out in an array. With regard to 100MW lasers, it is then necessary to achieve fuel flow rates of 700kg per second. At the present time, in the laboratory, option is made for the use of reaction devices that are very small. To prepare for the option to use large reaction devices, more assemblies are added. At the present time, TRW company and Luokedayin (phonetic) company are just in the midst of development. Besides this, AFWL is also in the midst of using moist wall reaction devices to carry out experiments. They use chlorine flowing past turning plates that have been moistened with alkaline hydrogen peroxide in order to produce excited states of oxygen, causing efficiencies to very, very greatly increase. AFWL is also studying TRW company's atomization type reaction device designs. These cause chlorine and alkaline hydrogen peroxide in the form of a fine mist to mix with each other in order to produce excited oxygen molecules,in large amounts.

In order to cause oxygen iodine lasers to penetrate the atmosphere, it is also necessary to use their frequency multiples. In April 1989, AFWL opted for the use of a high purity frequency multiplier crystal of lithium iodate, taking 1.3μm 10kW oxygen iodine laser output and multiplying it to 0.65μm. Power was 600-700W. It is, at the present time, the highest power continuous wave visible light laser in the world. Conversion efficiency reaches 5%-10%. In the next step, they will take crystals and place them in laser cavities. It is predicted that conversion efficiencies can rise to 20%. In order to shorten wave length and increase brightness, the U.S. is also in the midst of energetic exploration of new systems associated with visible light wave band chemical laser light. /30

--Quasimolecular Lasers. These were studied to make use of space based reflectors to carry out underwater submarine communications. Later, they were taken as a candidate by SDIO

for ground based laser weapons. Light beam quality associated with quasimolecular lasers is not good. Wave lengths are too short. Pulse width is very narrow. Repetition frequencies are not capable of making it very high. Therefore, in 1986, SDIO decided to shrink the scale of research associated with quasimolecular laser weapons. However, due to the fact that they are capable of acting as very strong radiation sources, they were used in tests of kill and damage power/vulnerability. They were also capable of developing into a tactical air defense or antisatellite weapon, and they were again kept on. The main oscillator in EMRLD already operated in 1988. Laser light was obtained of 0.35μm wave length. In each pulse, it is capable of producing 24J of energy. Output powers reach 5kW. This makes it into the western world's largest repetition pulse quasimolecular laser. However, due to the fact that EMRLD support costs and expenses associated with continued development of Raman pools and power amplifier subsystems were high in all cases, at the end of 1989, the Air Force, therefore, shut down the system. The Air Force also considered single pulse quasimolecular lasers. However, it was discovered that they were even more backward than the systems that were already on hand.

EMRLD is capable of producing blue light with wave lengths of 0.41-0.411μm. Repetition frequencies are 100Hz. It is composed of three main parts--main oscillator, power amplifier, and Raman pool. In main oscillators, using electricity, a gas mixture is stimulated, composed of xenon, nitrogen trifluoride, and small amounts of neon. 5kW low power laser pulses of 0.35μm wave length are produced. After that, in output amplifiers, option is made for the use of several megajoule electron guns, taking several coulomb charges and sending them to xenon chloride molecules in amplifiers--amplifying main oscillator output powers 10 times, reaching 50kW. Finally, light beams that have gone through amplification enter into Raman pools. In conjunction with this, there is mixing with coaxial blue colored seed light beams. The medium in Raman pools has been stimulated by high

energy ultraviolet light coming from high power amplifiers, making itself the equivalent of an amplifier associated with a blue colored seed light beam. Finally, 25-30kW 0.41μm blue light is produced. Light of this type of wave length is appropriate for propogation in the atmosphere.

GULF WAR PROMOTES THE DEVELOPMENT OF HIGH TECHNOLOGY WEAPONS

Xu Xing

Translation of "Hai Wan Zhan Zheng Tui Dong Le Gao Ji Shu Wu Qi De Fa Zhan"; Aerospace China, No.7, July 1991, pp 35-36

Desert Storm activities spurred the U.S. military to take the emphasis associated with weapons systems and put it on improving the quality of weapons systems. This improved the credibility with regard to high technology projects which are in the process of being carried out at the present time to an extremely great extent.

Despite the fact that officials associated with the U.S. Department of Defense opposed hastily drawing up future projects, they also recognized, however, that opting for the use of advanced technology tactical weapons systems in the Gulf War

played an important role. Therefore, in spite of fiscal tensions, the U.S. Defense Department still wants to continue accelerating development of high technology weapon systems in order to arm its combat units.

During the Gulf War, multinational unit loss rates in the air and on the ground were extremely low. This is clearly explained by the value of weapons systems--from precision guided weapons to portable types of global positioning system satellite navigation systems--associated with this type of technological advantage. These weapons systems, which opt for the use of advanced technologies, also aided multinational ground units to overcome the difficulties which come with combined operations.

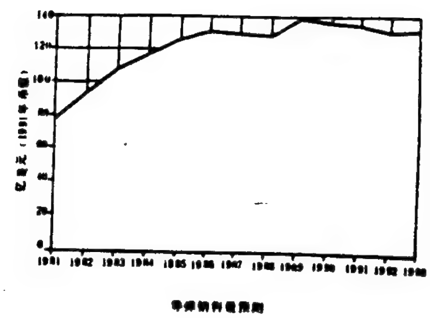
U.S. Defense Department officials say that, based on the experiences of the Gulf War, the direction of U.S. tactical weapons development projects will not undergo great changes. However, points of stress may possibly be adjusted, somewhat. The key now is how much new technology to opt for the use of in these tactical weapons.

Due to large amounts of cuts in military spending, it is necessary to use limited funds in order to balance relationships between research and development associated with new weapons systems and the procurement of currently existing weapons systems--which is a very thorny problem. This then compels the Defense Department to continue looking for currently existing systems, used in association with improvements, in order to take the place of new systems that need to be developed. However, due to the fact that, during the Gulf War, advanced weapons systems played an important role, in Congress, the pressure with regard to the development of advanced weapons systems abated. This won political support for the development of the next generation of weapons systems and guaranteed the U.S. would enter the next century using high quality weapons.

During the process of developing a good number of weapons, what legislative institutions criticized was the imperfect nature of technologies and costs that were too high. However, during the Gulf War, they still proved their value. These systems include the AH-64 Apache helicopter, Patriot air defense missiles, "Young Livestock" aerial antitank missiles, as well as Tomahawk cruise missiles, and so on.

The Gulf War also changed the ways of thinking associated with those who believed that the construction costs of advanced weapons systems were too high and the uses of weapons were very limited after the Soviet threat was reduced. For instance, in 1990, a number of legislators said that the U.S. no longer needed to monitor the activities of Soviet units deployed in Eastern Europe. For this reason, there was also no need to implement the E-8 target surveillance and attack joint radar system (Joint-STARS), that is, the J-STARS development project. However, during the Gulf War, aircraft equiped with Joint-STARS radar already demonstrated that they are very valuable.

[Unmarked Fig.]



Forecast Amounts of Missile Sales (1) 100 Million U.S. Dollars (1991 Currency Values)

Utilization of Joint-STARS radar during the Gulf War clearly showed that U.S. battlefield surveillance capabilities and the weapon combat capabilities were not appropriate to each other. The U.S. needs continuous, real time battlefield information. As far as tactical reconnaissance and other areas are concerned--in particular, when attacking ground targets--it is necessary to acquire real time target data in order to guarantee soldiers' being able to immediately fire toward targets. However, the U.S.

surveillance and reconnaissance capabilities which are currently on hand are not able to satisfy this requirement. During battles associated with multinational units precisely determining the positions of Iraqi Fleet Footed Runner (SCUD) missile mobile launchers, and, in conjunction with that, destroying them, this problem showed itself very prominently. This clearly shows that the U.S. needs to continue increasing surveillance and reconnaissance capabilities.

Besides Joint-STARS radar, during the Gulf War, U.S. units were also equiped with TR-1 reconnaissance aircraft which are capable of taking data and relaying it to mobile ground stations.

However, the coverage altitudes are limited. The U.S. also deployed RF-4C photoreconnaissance aircraft. However, the problems associated with excessively long film roll development times were not resolved.

The Gulf War also spurred the development of photoelectric systems. At the present time, the U.S. is in the midst of developing advanced tactical airborne reconnaissance systems which are capable of being mounted inside suspended compartments on F-16 aircraft. They are also capable of being installed on new models of intermediate range remotely piloted vehicles (RPV) which the U.S. is in the process of developing.

The F-117 attack plane, which opts for the use of stealth technology, attacked targets in the heavily defended skies above Baghdad, and preserved itself. In the earliest phases of the air war, the F-117 played a very great role. It broke through Iraq's air defense fire power, knocking out a number of Iraq's key radar bases and command and control centers. The success of the F-117 will also promote the development of stealth technology to an extremely great extent. /36

The Gulf War also promoted the rapid development of precision guided weapons with good performance. Desert Storm activities began the transition toward the utilization of this

type of "smart" weapon even more extensively.

From now on, in technological terms, the measures which will be adopted are weapons that make pilots able to launch outside of various types of defensive zones with the same kind of accuracies from places at even greater distances. This then requires developing a new generation of weapon systems launched outside defensive zones. The Air Force is just about to begin the deployment of this type of system. Among them are included AGM-130 rocket propelled gliding bombs and a good number of secret projects. The Navy is also in the midst of developing a type of similar system--the advanced sniping weapon system (AIWS) in order to replace laser guided bombs and "Young Livestock" missiles.

GERMANY DRAWS UP LONG TERM ASTRONAVIGATIONAL PLAN

Xie Xiaoguang

Translation of "De Guo Zhi Ding Chang Qi Hang Tian Gui Hua"; Aerospace China, No.7, July 1991, p 38

Following along with the unification of east and west Germany, the astronavigational plans of the two sides have also been made one by combining two. However, in 1991, the astronavigational budget of the former east German part was only equivalent to 100 million west German marks. The German government after unification put forward a total astronavigational budget for 1991 which was 1.566 billion marks. The two sides put together increased 9.6% compared to 1990.

In the period of years from 1986-1991, the expenditures provided by Germany for the European Space Agency increased from 460 million marks to more than 1 billion marks. As far as 1991 is concerned, Germany will provide expenditures for the European Space agency that are 500 million units of unified European currency. This accounts for 20.5% of the total expenditures of

the European Space Agency--second only to France (their investment is close to 25%). The German investment in the Gelunbu (phonetic) project was 850 million marks--accounting for 27% of the total expenditures. For Arian 5 the investment was 800 million marks--acounting for 22% of the total expenditures.

The German space agency (DARA) is prepared, in early summer 1991, to draw up a new 10 year financial plan right up to the year 2000 and a 20 year strategic plan right out to the year 2010. This long term strategic plan includes a number of cooperative international projects--for example, such ambitious and energetic items as the reusable Sengeer (phonetic) space shuttle as well as a permanently inhabited moon base, and so on.

Seen in recent terms, Germany's new astronavigational plan has already placed emphasis on space research, satellite surveying, microgravity research, as well as communications and other space applications.

DARA is preparing, within 10 years, to take satellite survey project expenditures and increase them two fold--increasing from 1990's 140 million marks to over 400 million marks in the year 2000. In this area, work that has already been developed includes the first batch of European radar survey satellites--ERS-1 and ERS-2--developed by the Daonier (phonetic) company. They will, respectively, be launched using Arian rockets in May of 1991 and the end of 1994. In another area, the Daonier (phonetic) company has also cooperatively developed X-SAR radar with the Italian Alenia company (formerly the Sailieniya [phonetic] astronavigational company). Development work will be concluded in 1991. This cooperatively developed German-Italian synthetic aperture radar unit will be made use of with the SIR-C radar set on the U.S. space shuttle in 1993. The Daonier (phonetic) company will also develop a type of improved model satellite which takes the name of X-EOS. It will be fitted with

a unit of drive model antenna radar. Development work will begin in 1995. There are preparations to launch in the year 2000.

The main satellite survey project is the polar orbit satellite Atmos associated with atmospheric research. This engineering project is carried out cooperatively by the Daonier (phonetic) company and MBB as well as the OHB company. The weight of the Atmos satellite is approximately 1500kg. It has a useful load of 650kg. It will use Arian or Delta rockets to be sent into a 775km high polar orbit. This ecological satellite is fitted with 4 or 5 types of sensors (spectral instruments, interferometers, atmospheric detectors, and so on) and is capable of being used in order to study the desertification of land, the reduction of forests, pollution of the oceans, thinning of the ozone layer, greenhouse effects, and so forth. If this project is able to begin in 1991, this ecological satellite will then be able to be launched at the end of 1995. At the present time, it is estimated that this project will cost at least 800 million marks. Therefore, it is not very likely that it will be carried out by Germany alone.

As far as activities associated with the area of microgravity experiments are concerned, tests are carried out using satellites or sounding rockets Texus and Maxus. Maxus was jointly developed by Germany (MBB) and Sweden. It will be launched from Jilyuna (phonetic) Sweden and will be Europe's largest sounding rocket. It weighs 12.3 tons. The useful load is 420kg. Maxus will be able to supply 15 minutes of microgravity experimentation time. However, Texus only has 6-8 minutes. Besides this, in September of this year, a free falling body tower reaching a height of 146 meters goes into service in Bremen.

After the unification of east and west Germany--with the aid of relationships established between the former East Germany and Soviet Union--the scale of cooperation between Germany and the

Soviets will get larger and larger. Germany is going to participate in the Soviet Union's 1994 Mars probe project, supplying billion bit large model memories and a high resolution stereoscopic camera.

In 1992, a German cosmonaut will stay a week in the orbiting station Peace. Bonn will be responsible for 21 million marks on this flight. There are also two German astronauts prepared, in 1992, to ride the U.S. space shuttle to carry out Spacelab D2 missions. Besides this, candidate crew personnel will also be selected for Gelunbu (phonetic) and Mercury.

After that, Germany is also thinking of using the Sengeer (phonetic) space shuttle to replace the Mercury space shuttle. At the present time, MBB and MTU are in the midst of carrying out preliminary studies. This work will be concluded by the end of 1992. Sengeer (phonetic) will be composed of two stages. The first stage weighs 254 tons. The second stage weighs 112 tons. This is carried by the first stage. Sengeer (phonetic) opts for the use of turbo-ram type composite engines for propulsion. It is capable of taking a useful load of 7.5 tons and sending it into a 200km orbit and taking a 6 ton useful load and sending it into an orbital station orbit of 460km. At the same time, MBB and MTU are also studying a type of high supersonic experimental craft, Hytex, which is capable of reaching altitudes of 30km with weights of 18 tons. This aircraft begins flights in 1998. The test flight period associated with Mercury will be delayed to the years 2000-2001. As far as the Sengeer (phonetic) space shuttle is concerned, development will only be possible after at least the year 2012.

THE SOVIET UNION MAKES PUBLIC A NUMBER OF NEW WEAPONS SYSTEMS

Xu Fuxing

Translation of "Su Lian Gong Kai Yi Xie Xin Wu Qi Xi Tong"; Aerospace China, No.7, July 1991, p 43

According to reports in a January 1991 "Janes Defense Weekly", at the first defense exposition held in Manila, the Soviet Union made public for the first time a number of new weapons systems. Among these were included the SA-15 self-propelled surface to air missile, a type of vehicle borne AT-6 Screw antitank guided weapon system, and the SA-10 Grumble missile. This clearly shows that the Soviet Union is in the process of exerting all possible efforts to open up new markets for its defense weapons. For many years, all the weapons exported by the Soviet Union were comparatively obsolete. However, at the Manila exposition, a number of new weapons, which had not been made public before, were still displayed.

[Unmarked Fig.]

裝有8枚SA-15導彈的Tor系統

Tor System Equiped with 8 SA-15 Missiles

The SA-15 is mounted on the same tank chassis as the 2S6 self-propelled air defense artillery/missile launcher made public last year. However, it has a new revolving turret without a human operator. On top there are fitted 8 vertically launched missiles which are the same as the Soviet Navy's SA-N-6 air defense system. These missiles are divided into two assemblies. Each assembly has 4 missiles. Each missile is sealed inside a storage transport box. It is not necessary to carry out maintenance. Another vehicle fitted with a crane takes charge of reloading missiles. Specific details are not yet clear. A tracking radar is installed in front of the turret. A surveillance radar is mounted in back. During the process of transport, the two radar units are both capable of being packed up.

Missiles use cold launch methods of firing. After flying 18-20 meters, thrust devices begin to operate, making the missile fly in the direction of the target. In conjunction with this, solid motors ignite. On the basis of estimates, the overall length of the missile is approximately 3.5 meters. The diameter of the missile is 0.35 meters. The weight is approximately 170kg.

The maximum range of the SA-15 is 12km. It is capable of hitting aircraft flying at altitudes of 10-6000 meters. The maximum flight speed of the missile in question is 850m/sec. Maneuver overloads associated with this type of command guided missile are capable of reaching 30g. The missiles are fitted

with prefabricated fragmentation high explosive warheads detonated by proximity fuses and weighing 15kg. The SA-15 missile was developed at Anty. A good number of other land based and sea based systems were also developed here. Among these are included the SA-8 Gaike (phonetic) missile. This type of missile has already been exported to a good number of nations and regions. In conjunction with this, they are used in Africa and Middle East wars.

The AT-6 Screw antitank guided weapon is capable of being fired from the Mi-24 "She Tiger E/F" and the Mi-28 Great Calamity helicopters. At the present time, MT-LB multipurpose amphibious armored vehicles are also capable of mounting and firing AT-6 missiles. Each armored vehicle is capable of mounting a total of 12 missiles.

The diameter of AT-6 missiles is 130mm. Length is approximately 1.38m. Including the firing tube, overall weight is 46.5kg. The maximum range of the missile in question is 5km. It opts for the use of radio guidance. On MT-LB, missiles are mounted on racks on the back part of armored vehicles. They are capable of being raised to 90°, carrying out vertical firing. Aiming systems, by contrast, are installed on the front part of vehicles.

The range of the SA-10 exceeds 100km. It is capable of intercepting targets at altitudes from 25 meters to 3 thousand meters. The SA-10 is a type of highly mobile surface system mounted on an 8x8 cross country vehicle chassis. Due to the fact that various pieces of equipment do not make use of electric cables to connect with each other, it is, therefore, then possible to make firing preparations in less than 5 minutes.

The SA-10 system makes use of a multiple function phase control array radar unit, a firing rack which is capable of carrying 4 missiles, and a missile supply vehicle mounted with another 4 missiles. Multiple function phase control radar and the radar associated with the Raytheon company's Patriot surface to air system are similar. It is possible to track 6 individual

targets. In conjunction with this, it is possible to guide two missiles to attack one target between them. According to what the Soviet Union says, the radar in question possesses very strong counter electronic jamming capabilities.